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(54) **Bonded Fabric of Multifilament Core Yarn**

(57) A woven or non-woven fabric (21) is prepared from a latent foam-encapsulated and impregnated multifilament yarn (22, 23). A multifilament yarn is dipped into a resin and a blowing agent, and is then drawn through a die. The dipped yarn (22, 23), after drying, is then formed into a fabric. The fabric is subsequently taken to a temperature high enough to activate the blowing agent under conditions such that cross-over points (23, 24) of the fabric (21) are bonded together, and the yarns (22, 23), themselves, are flattened. To maximise the flattening effect, the multifilament yarns are maintained with little or no twist.

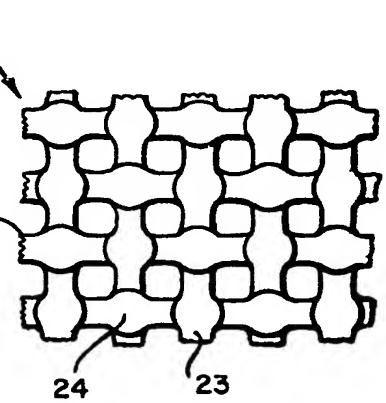


*FIG. 4*

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FIG. 1
PRIOR ART

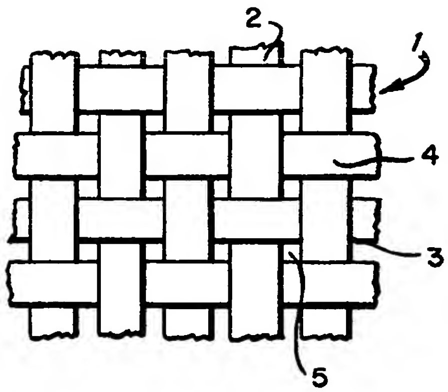



FIG. 2a
PRIOR ART

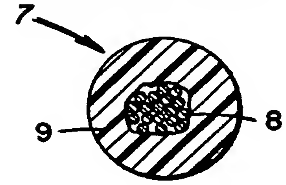
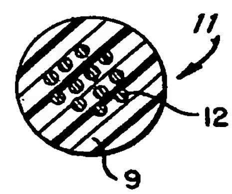



FIG. 2b



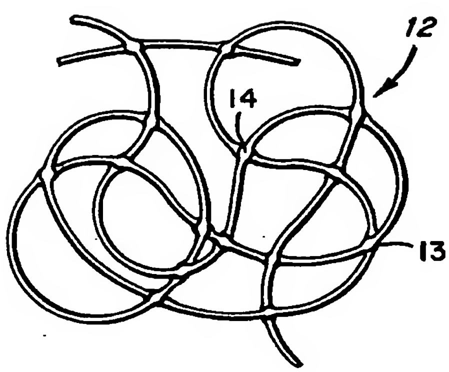
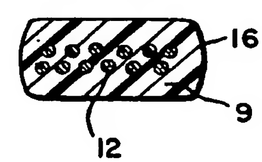




FIG. 3

FIG. 2c



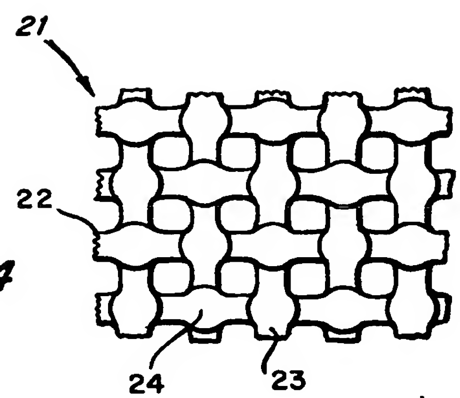
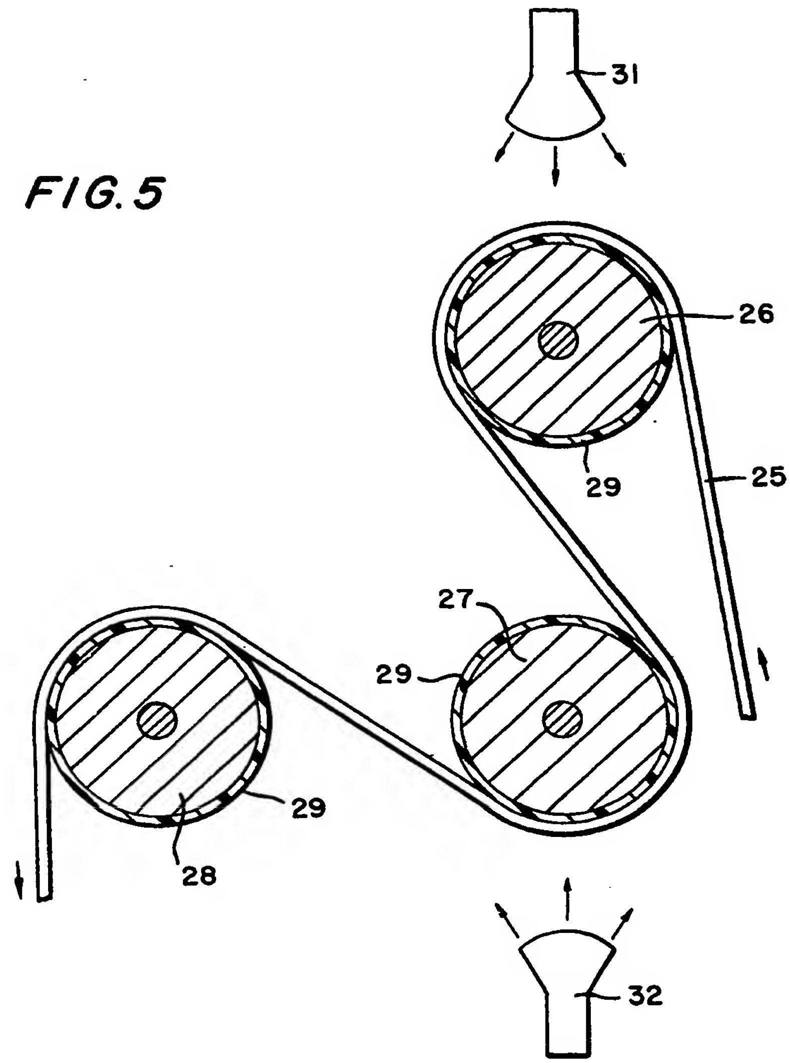




FIG. 4

FIG. 5



SPECIFICATION

**Method of Preparing Flattened and Bonded Fabric of Foamed Vinyl Plastisol on a Multifilament Core**

The production of vinyl-coated synthetic yarns, where the vinyl coating or encapsulation contains an unactivated foaming agent, is well known. In general, the synthetic yarns are continuous filament or multifilament yarns ranging from about 150 to about 2,200 denier, the yarns, themselves, generally being of nylon, rayon, glass or polyester. The synthetic core yarn is completely encapsulated in the cured vinyl plastisol by extrusion, and a cross-section of the coated yarn shows that where the core yarn is a multifilament, the vinyl compound is only slightly interspersed, at best, among the individual filaments. Such a construction gives good adhesion to the core yarn; however, the major portion of the vinyl resin surrounds and encapsulates the core yarn. Normally, the vinyl content of the final yarn ranges from 50 to 90% by weight thereof.

An important use for such a yarn is in the preparation of fabrics, either woven or non-woven. A key feature in the process by which the fabrics are produced is that it must be possible to prepare the yarn in cured form without activating the foaming agent therein. While it is possible to prepare a fabric from the yarn after activation of the foaming agent, the process is uneconomical and the resultant fabric is inferior to the case wherein the process steps include curing of the yarn without activation of the foaming agent prior to preparation of a fabric and activation of the foaming agent subsequent to manufacture of the fabric.

For numerous applications, it is also important to provide a relatively closed fabric with minimum materials. In this regard, the closeness of a fabric is generally dependent upon the diameters of the yarns and the numbers of yarns per inch in both the warp and weft directions. Accordingly, reduction of costs in a closed fabric is quite difficult to attain.

Richmond, in U.S Patent No. 3,100,926 has described a fabric wherein yarns are prepared in an extrusion process from a mixture of a thermoplastic resin and a blowing agent. The extruded yarns are then formed into a fabric-like material which, in turn, is thermally treated to decompose the blowing agent and evolve gases which have the dual effect of expanding the thermoplastic yarn and welding the thermally-softened yarns at juncture points in a permanent bond. Richmond shows both a non-woven fabric and a number of woven fabrics. In general, although extrusion coating provides very little flattening, the woven fabrics are made such that there is little, if any, open area; in this manner, such fabrics serve to screen a region completely from view, when used as curtains or area dividers. As is evident, it is the thickness of the yarn in the plane of the fabric rather than in the transverse direction which is significant in determining the 'opacity' of 'shade-factor' of the fabric. If a thin yarn is to be used to produce a desired degree of opacity, then a large number of picks must be used. Conversely, if a thick yarn is used, then the quantity of encapsulating material necessary is high and the material cost is high.

A further difficulty with the process as disclosed by Richmond is that the extrusion temperature must be controlled within relatively narrow limits since any undue elevation of temperature during the extrusion can result in partial or complete activation of the foaming agent. Even more importantly, by the extrusion process, no more than a small number of yarns, such as two or three, can be processed simultaneously by a single extruder due to the practical difficulties of dealing with yarn ends of finite length, breakage of the yarn, and keeping the ends separate as they leave the single die. As is evident, then, the difficulties inherent in the extrusion process for preparing a fabric as described herein, both with respect to control of the process and with respect to the essentially cylindrical shape of the yarn in its expanded form, would make it desirable that a more effective and economical process and product be devoloped.

The primary object of the present invention is to provide a method for producing a coated yarn which can be used in the production of a woven or non-woven fabric of the aforesaid kind but which avoids the disadvantages inherent in the prior art method.

In its broadest aspect a method of producing yarns for woven or non-woven fabrics comprises, in sequence, the steps of applying a resinous coating material containing an effective amount of a foaming agent as a viscous liquid to a multifilament core yarn to encapsulate and impregnate said yarn, the activation temperature of said foaming agent being higher than curing temperature of said resinous coating material, and curing said yarn at least to a degree such that said yarn can withstand subsequent stresses in forming into a finished fabric, said degree ranging from partial cure to full cure, at a temperature below that at which said foaming agent is activated.

Thus, an organic filament yarn of materials such as rayon, nylon, or polyester, or an inorganic filament yarn of materials such as glass, is coated, as by dipping, with a viscous plastisol such as polyvinyl chloride together with one or more plasticizers, a foaming agent and optionally, fillers, colouring material, inhibitors, etc.; is drawn through a die to control the thickness of the coating, and is cured at a temperature low enough so that the foaming agent is not activated. As is evident, the foaming agent must be selected to have an activation temperature which is substantially higher than the curing temperature of the plastisol. Further, the filament yarn is a multifilament, and is preferably maintained at little or no twist so that the plastisol impregnates the multifilament yarn, as well as encapsulates the same. The sequence of steps,

consisting of encapsulation, drawing through a die, and curing below the activation temperature of the foam, may be repeated one or more times, as desired, the diameter of the die being inceased each time. Most important, a large number of yarns or ends can be formed and processed simultaneously in a single apparatus.

The term "cure" as used herein denotes cure at least to the stage where the plastisol can withstand subsequent stresses such as are encountered in forming into a fabric, tentering, calendering and foaming under tension. Full cure produces the maximum tensile strength. Partial cure of the yarn subsequent to each coating step allows for more rapid processing than when the yarn is fully cured at this stage. Where the yarn is only partially cured after coating, the final cure is effected during subsequent blowing. i.e., foaming.

The temperature and duration of exposure to heat for producing partial cure will vary with the plastisol and the thickness thereof. Exposure to 380°F air for five to six seconds is a suitable set of conditions in many cases. However, for each case, suitable conditions may readily be determined by one skilled in the art.

After producing a cured yarn of the desired diameter, the yarn being essentially circular in cross-section, the yarn is formed into a fabric, either woven or non-woven. After forming into a fabric, the fabric is heated to activate the foaming agent and to soften the yarn. Some flattening takes place during the heating step due to the tension generated by shrinking of the yarn when the yarn is organic. Also, where the yarn has been only partially cured, full cure is effected during the foaming operation. Finally, the fabric may be further flattened as by calendering or by tentering while heating. The tenter frame subjects the fabric to tension in both the warp and fill directions, partially flattening the fabric in the process. Surprisingly, the fabric flattens most at junctions between the warp and fill yarns, welding of the warp and fill yarns to each other taking place at junctions. The bond formed in this way is permanent. Further flattening of the fabric can be accomplished by passing the hot fabric through a calender.

In the flattening process, the open area between the yarns is decreased, the decrease being proportional to the twist of the yarn filaments, the tension placed upon the yarns, and the pressure of the rolls used in calendering. By these techniques, the fraction of the fabric which is open can be controlled. Such control is desirable both with respect to control of traversal of the fabric by light or by moving air. In the calendering operation, the yarn may be flattened between juctions to essentially the same degree as at junctions.

Yet another method of flattening a woven fabric is to draw the fabric over a succession of rolls under tension, and to heat the fabric, as by infra-red or by hot air, to the point where the yarns are blown and then flattened. Preferably, the rolls are arranged so that both faces of the fabric are exposed in sequence to the heat source. Either one or both faces of the fabric may be flattened by this process.

The invention will now be described further, by way of example only, with reference to the accompanying drawings in which:—

Fig. 1 shows an expanded fabric in accordance with the prior art;

Fig. 2a is a sectional view of an extrusion-encapsulated multifilament yarn in accordance with the prior art;

Fig. 2b is a sectional view of an encapsulated and impregnated multifilament yarn formed in accordance with the teachings of the present invention;

Fig. 2c is a sectional view of the yarn shown in Fig. 2b, but after flattening in accordance with the teachings of the present invention;

Fig. 3 is a non-woven flattened fabric formed in accordance with the teachings of the present invention;

Fig. 4 is an illustration of a woven fabric expanded and flattened in accordance with the teachings of the present invention; and

Fig. 5 shows an apparatus for foaming and flattening a fabric in accordance with the present invention.

In accordance with the invention, a multifilament yarn is encapsulated and impregnated with a plastisol; passed through a die so that the coating on the yarn may be essentially circular in cross-section; and cured; either partially or completely. The plastisol is generally polyvinyl chloride in combination with plasticizer, stabilizer, inhibitor and, especially, a foaming agent which, for activation, requires a temperature higher than the curing temperature of the plastisol. The encapsulated and impregnated yarn is then cured at a temperature below the activation temperature of the foaming, or blowing agent.

It is known to prepare a fabric, either woven or non-woven, from a somewhat similar yarn formed by extrusion. Such a fabric is shown in Fig. 1, where a woven fabric is represented generally by the reference numeral 1, the fabric being woven of warp yarns 2 and fill yarns 3. The warp and fill yarns are welded together at junctions such as that indicated by the reference numeral 4. As can be seen, the open area which consists of the spaces between the yarns, a representative space being indicated by the reference numeral 5, is relatively small; where such a fabric is used as a windscreen or to provide shade or privacy, it is desirable that the openings 5 be small relative to the total area. However, as noted above, the manufacture of these types of fabrics from prior art techniques is quite expensive. For when yarns are coated by the extrusion process, as in the aforementioned Richmond U.S. Patent No. 3,100,926, flattening of the yarns is minimal, and hence the manufacture of a relatively closed fabric requires a high number of yarns per inch.

In Fig. 2a a multifilament yarn, encapsulated by extrusion, is indicated generally by the reference

numeral 7. The yarn 7, comprising a central multifilament core 8 of a material such as rayon, nylon, glass or polyester, is encapsulated in a plastisol 9. As can be seen, the plastisol 9 encapsulates the core yarn 8, but does not impregnate the boundary of the core. With only encapsulation, relatively little flattening is possible. With reference, then, to Figs. 2b and 2c, the manner in which the present invention overcomes the difficulties of the prior art can be seen. In Fig. 2b, a multifilament yarn formed in accordance with the inventive process, can be seen. Here, the yarn is represented generally by the reference numeral 11, and includes a multifilament core yarn 12 and a plastisol coating 9. As can be seen, coating 9 not only encapsulates core 12, but impregnates the same; this impregnation significantly incrases the ultimate amount of yarn flattening.

The plastisol generally is a plasticized vinyl compound containing 50 to 60% of polyvinyl chloride resin and 50 to 40% of plasticizers, fillers, pigments, stabilizers and other conventional additives. In addition, the plastisol incorporates a blowing, or foaming agent. A blowing agent is selected so as to have an activation temperature substantially higher than the curing temperature of the plastisol. The quantity of blowing agent present, depends upon the degree of expansion desired. A typical quantity of blowing agent may be such that a cured yarn which is 0.028 inches in diameter expands to approximately 0.054 inches in diameter. The core yarn is preferably of polyester.

The plastisol-coated and impregnated yarn is drawn through a circular die to give it the shape shown in Fig. 2b, after which it is cured or partially cured at a temperature below the activation temperature of the blowing agent. The sequence of steps, namely, coating, sizing by means of a die, and curing, preferably is repeated once, and if desired, more than once. The purpose, of course, is to increase the final diameter of the cured yarn. As aforenoted, the cure may be either partial (elimination of tackiness and providing adequate mechanical strength to withstand subsequent processing), or full.

Significantly, the inventive process enables as many as 80 or more yarns or "ends" to simultaneously be processed. simultaneously processing a plurality of yarns results in a substantial reduction of cost, especially since a single oven will suffice for almost any number of yarns. The operating temperature of the cure oven is limited by the necessity to stay below the temperature of activation of the blowing agent. The lenngth of the oven, where the yarn is moved horizontally, is limited by the increasing sag of the yarn, supported only at the ends. It is in the interest of increasing the production rate that the yarn is taken so rapidly through the oven that it is only partially cured.

After curing, the yarn can be formed into a non-woven fabric such as is shown in Fig. 3, the fabric being represented generally by the reference numeral 12. After forming into the non-woven fabric 12, the fabric is heated to a temperature sufficient to activate the blowing agent, and to weld the yarns at their junctions; flattening occurs at such junctions. While soft, the fabric may further be calendered so that the junctions formed by crossing yarns such as at 13 and 14 are further flattened. Also, in the calendering process, the yarns are flattened between junctions as well, so that they have cross sections as shown in Fig. 2c, where yarn 16 is comprised of a multifilament core yarn 12 encased in and impregnated with plastisol 9.

As is evident, using the inventive process described above, the yarn is flattened in the plane of the fabric, thus decreasing the size of the open spaces. Consequently, a desired shade factor can be achived with a smaller weight of yarn, or number of yarns per inch, than would be the case were the yarn circular in cross-section; the inventive process exhibits the same advantage over an extruded yarn, where flattening is limited.

Where a woven fabric is prepared from the yarn prepared in accordance with the inventive process, the fabric can be heated to soften the yarns and to activate the blowing agent, either in tentering or in calendering, exactly as in the case of the non-woven fabric illustrated in Fig. 3. Surprisingly, it is found that the fabric is flattened, by heating under tension, to a greater extent at the junction points; this is illustrated in Fig. 4 where the fabric, generally indicated by the reference numeral 21, consists of warp yarns 22 and fill yarns 23. Flattening is greatest at junction points of which junction 24 is representative. Each warp yarn is bonded to each fill yarn in the heating process. Moreover, the fraction of the total area of the fabric which is open can readily be established by the tension during tentering and by controlled calendering.

An alternate method of expanding the blowing agent and flattening woven fabric is illustrated in Fig. 5, wherein fabric 25 is passed over roll 26 and heated sufficiently, as by infra-red source 31 or by hot air, to cause blowing and softening of one face of the fabric. The fabric is then carried over roll 27, in a direction such as to bring the softened face of the fabric against roll 27, to flatten the outer face of the fabric and weld the yarns at junctions betwen warp and fill. Foaming of the other face of the fabric is effected by heating with a heat source 32. If it is desired that both faces of the fabric be flattened, the fabric, while still soft, is taken over roll 28 under tension. Where the fabric is of partially-cured yarns, the cure is completed during the foaming operation.

It is essential that the temperature of the various rolls be held below that at which the softened fabric will adhere to the roll surface. This temperature can readily be determined by those skilled in the art. The rolls conveniently, may be cooled from their interiors, should this step prove necessary.

As noted above, the preferred filament is

polyester. This fabric has tendency to shrink at the foaming temperature, and this is the major reason for carrying out the foaming, flattening and welding operations under tension. Tentering overcomes the tendency to shrink, both in the warp and fill directions, but in a loosely-woven fabric, the selvedge of the fabric may be pulled loose. This difficulty is eliminated by the process illustrated in Fig. 5, but the fabric exhibits some tendency to shrinkage in the fill direction when processed in this way. The shrinkage in the fill direction can be minimized by holding the fabric tightly against the various rolls. The shrinkage is virtually eliminated by increasing the coefficient of friction betwen the fabric and the roll. This can be effected by roughening the surface of the rolls or by coating the rolls with a layer 29 of a high-friction material such as silicone rubber.

Where the fabric is to be used to provide shade, the opacity of the fabric should be relatively high. However, even where the fabric is to be used for shade purposes, it is generally desirable that the cooling effect of a breeze be available. for this purpose, open area in the fabric must be provided. Such open areas are provided by the inventive fabrics, which have been found suitable for awnings, screens between road lanes for opposite direction, and between adjacent tennis courts, for truck tarpaulins, furniture fabric, and for fluorescent safety clothing of light weight. Where the fabric is to be used for fencing, the openings may be as large as 2″×2″. Thus, the open area may vary from essentially zero up to about 99%.

The continuous filament yarns to be encapsulated may range generally from about 70 to about 2,200 denier. Normally, the vinyl plastisol coating comprises 50 to 90% of the total weight of the resultant yarn. Conveniently, yarn consisting of a single coating on a core 12 mils in diameter may be 20 mils in diameter, each successive coating increasing the diameter by 8 mils. As is evident, the die through which the yarn is drawn after each successive coating must be larger in size than the die used in connection with the previous coating. Also, each newly applied coating must be cured to the desired degree after drawing through the sizing die, the cure being carried out at a temperature below that at which the blowing agent is activated.

As an example of the inventive process, a continuous filament polyester yarn of 1,000 denier is double-coated to a diameter of 28 mils with a latent foam vinyl coating. This yarn has a weight of approximately one pound per thousand yarns, and is generally circular in cross-section with the core yarn well protected as an inner core. The cured yarn may be woven into a construction of six picks per inch in both fill and warp. The fabric is then passed through a tenter frame at which time the fabric is held taut in both the fill and warp directions. Hot air at approximately 375°F is passed through the fabric, causing the vinyl to soften and the blowing agent to release. Under these conditions, the yarn expands from 28 mils to approximately 54 mils. At the same time, the tensions being applied to the fabric cause the yarns to flatten at the points where warp and fill cross, bonding taking place at each of these points. The result is a very stable fabric of foamed, flat vinyl-coated yarns lying in the fill and warp directions. Flattening is greater at the cross-over points, due in part to the pressure on the yarns at such points. The width of the yarn is increased to approximately 65 mils, the yarn simultaneously becoming smaller in thickness. As noted above, by maintaining the filaments of the multifilament are in a substantially no-twist condition, flattening of the yarns during the foaming operation is maximized.

Further flattening can be accomplished by calendering the fabric while it is still soft. A round 28 mil yarn in a woven construction can be flattened to 90 mils in width while still protecting the core yarn and retaining 30% of the foam structure. Flattening by the three-rolls process illustrated in Fig. 5 yields an essentially similar product.

The product has great resistance to outdoor weathering and can be produced in a multitude of colours. The product also has good abrasion resistance, and the core yarn is protected from deterioration by sunlight. It can be used for outdoor fencing around gardens, patios, miscellaneous enclosures, and especially for fencing material to cut down the glare of lights betwen parallel opposing lanes of traffic on a highway. It can also be used for barrier fences in ski areas, for home shade cloth, and for protection against wind. Depending on the open area, both controlled visibility and air-flow can be achieved.

The materials used are conventional and are readily available. for instance, a suitable blowing agent is azodicarbonamide, which decomposes at between 302 and 392°F which is sold under the name of Azocel, and which is manufactured by Fairmount Chemical Company, Inc., Newark, New Jersey.

It is intended that all matter contained in the above description and shown in the accompanying drawings, shall be interpreted as illustrative and not in a limiting sense. It is also to be understood that the following claims are intended to cover all of the generic and specific features of the invention herein described.

**Claims**

1. A method of producing yarns for woven or non-woven fabrics comprising, in sequence, the steps of applying a resinous coating material containing an effective amount of a foaming agent as a viscous liquid to a multifilament core yarn to encapsulate and impregnate said yarn, the activation temperature of said foaming agent being higher than curing temperature of said resinous coating material, and curing said yarn at least to a degree such that said yarn can withstand subsequent stresses in forming into a finished fabric, said degree ranging from partial cure to full cure, at a temperature below that at

which said foaming agent is activated.

2. The method as claimed in claim 1, wherein said resinous coating material comprises a plastisol compound.

3. The method as claimed in claim 1 or 2, including the step of drawing said encapsulated and impregnated core yarn through a sizing die to bring the core yarn to a selected thickness.

4. The method as claimed in claim 3, wherein said sequence of encapsulation and impregnation, sizing, and curing, is repeated at least once, the aperture of the sizing die being increased by a selected amount at each repetition of said sequence.

5. The method as claimed in any one of the preceding claims, wherein the filaments of said multifilament core yarn are maintained in an essentially zero-twist condition.

6. The method as claimed in any one of the preceding claims, wherein said multifilament yarn is a polyester, rayon, glass or nylon.

7. The method as claimed in claim 6, wherein said multifilament yarn is a polyester.

8. The method as claimed in any one of the preceding claims, wherein said filament yarn is of nylon, rayon or polyester in a size ranging from about 70 to 2200 denier.

9. The method as claimed in any one of the preceding claims, wherein the filaments of said multifilament core are maintained in an essentially zero-twist condition.

10. The method as claimed in any one of the preceding claims, wherein a plurality of yarns are manufactured simultaneously.

11. A method of producing a fabric from yarn as claimed in any one of the preceding claims, which comprises the steps of combining a plurality of such yarns to provide a fabric and heating said fabric to a temperature high enough to activate said foaming agent and to soften the fabric, thereby simultaneously expanding and flattening said yarns and bonding said yarns together at their junctions.

12. The method as claimed in claim 11, wherein the yarns are combined by a weaving process to give a woven fabric.

13. The method as claimed in claim 12, further comprising the step of heating said fabric in a tenter frame which applies tension to said fabric in both the warp and fill directions.

14. The method as claimed in any one of claims 11 to 13, further comprising the step of calendering said fabric while said fabric is in softened condition, thereby further flattening said fabric and reducing the open area thereof.

15. The method as claimed in claim 13, wherein said filament yarn is about 1000 denier, after encapsulating and curing the resultant yarn is about 0.028 inches in diameter and the quantity of foaming agent is such that, on activation, said foaming agent expands said yarn to a diameter of approximately 0.059 inches.

16. The method as claimed in claim 15, wherein the tension applied during tentering is such as to flatten said yarn to about 0.090 inches in width.

17. A method as claimed in claim 12, wherein said foaming agent is activated by the steps of passing said woven fabric over a first roll, heating a first face of said fabric, being that face remote from said first roll, to a temperature sufficient to complete the cure of said yarn where only partially cured, to foam said yarn and to soften the same, and passing said fabric over a second roll in a direction such that said first face of said fabric makes contact with said second roll, said fabric being under tension in the warp direction, whereby said first face of said fabric is flattened and the yarns of said fabric are welded together at junctions of warp and fill yarns.

18. The method as claimed in claim 17, further comprising the steps of heating a second face of said fabric, being that face opposite said first face, to a temperature high enough to complete the cure of said second face of said fabric where the yarns comprising said second face are only partially cured, to foam the yarns of said second face and to soften same; and passing said fabric over a third roll under tension in the warp direction with said second face making contact with said third roll while still soft, whereby said second face is flattened.

19. The method as claimed in claim 17 or 18, including the step of providing a surface of high coefficient-of-friction for contact by said fabric for the purpose of minimizing or eliminating shrinkage in the fill direction.

20. The method of producing a fabric of a flattened impregnated and encapsulated yarn, the method comprising the steps of: weaving a fabric of yarns having a multifilament core coated with a foaming agent and a resin which are applied to said core as a viscous liquid; heating said woven fabric to a temperature high enough to activate said foaming agent and soften the fabric, thereby simultaneously expanding and flattening said yarns and bonding said yarns at the points where warp and fill yarns cross.

New claim filed on 10 September 1979.
Superseded claim 15

**New or amended claim:—**

15. The method as claimed in claim 13, wherein said filament yarn is about 1000 denier, after encapsulating and curing the resultant yarn is about 0.028 inches in diameter and the quantity of foaming agent is such that, on activation, said foaming agent expands said yarn to a diameter of approximately 0.054 inches.

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